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Heads UP!

P.J. Medina is shown installing photomultiplier tubes to the Mini-CAPTAIN detector that ran at the Lab's Weapons Neutron Research Facility. The addition was critical to the success of the instrument's photon sensing system.



## In memoriam: P.J. Medina, Jr.

*Coworkers saw young P-23 technician as a rising star, future Lab leader*

*By H. Kris Fronzak, ADEPS Communications*

Patrick "PJ" Medina, Jr., a fiber optic technician in Neutron Science and Technology (P-23), was only 21 years old, but had already earned a Los Alamos Distinguished Performance Award and the admiration of those who worked with him when he passed away recently in a car accident.

"After several months working here, it became clear that he was incredibly smart as well as self-motivated and self-directed. That's your ideal Laboratory leader; I saw in him the potential to become a senior engineer," said Matthew Murray (P-23), his mentor for three years. "His death was a deep loss for the Laboratory and it broke a lot of our hearts."

A 2014 Peñasco High School graduate, Medina's first exposure to the Laboratory was through its High School Internship Program. As part of Subatomic Physics (P-25), he helped scientists prepare explosive shots at the Proton Radiography Facility at the Los Alamos Neutron Science

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“

*The holiday season is starting. I wish all of you and your families a safe and happy season. And I remind you that this can be a season of distractions, so please pay extra attention to do your jobs safely and securely.*

”

*David*

## From David's desk ...

Unfortunately, we start this issue with two more memorials. As mentioned in my previous “From David’s Desk,” Geoff Mills (P-25) died on July 3 after a long battle with cancer. On August 11, P.J. Medina Jr. (P-23) died in a car accident. He had been interviewed for this issue of *Physics Flash* with that interview forming the basis of the memorial. I send my sincerest condolences to the families, friends, and co-workers. It was a tough summer for the division.

It is a continued pleasure to observe the awards that members of the division receive. Some of the recent awards are highlighted in this issue, including Ray Newell (P-21) receiving the 2016 Richard P. Feynman Innovation Prize, Kiersten Haffey (P-21) winning an outstanding physics poster award at the 2017 Student Symposium, and three 2016 Distinguished Performance Awards (DPAs). The Fuel Cask Tomography and the Ultracold Neutron Source teams (both P-25) received Small Team DPAs. The pRad Experimental 0631 Team (P-21, P-23, P-24, P-25) received a Large Team DPA. It is always a pleasure to attend the presentations of the awards.

Brenda Dingus (P-23) was awarded the 2017 Medal by the Division of Particles and Fields of the Mexican Physical Society “por su enorme contribución al desarrollo de los físicos mexicanos en el observatorio HAWC y su contribución a que se seleccionara México para instalar aquí el Observatorio HAWC.” While I don’t speak Spanish, at least not yet, I can figure out the gist of this. The Google translation is included at the end of this article.\*

In October, I attended the annual American Physical Society (APS) Division of Plasma Physics (DPP) Meeting in Milwaukee. I was able to see a number of presentations from P-23 and P-24, as well as LANL’s student fair and recruiting booths. This meeting marked the official end of my four-year term in the APS/DPP chair line. While the final year, as past chair, did not require significant work, the first three did. While I am happy to have served the APS, I am glad that the term is over and I won’t have to do it again.

This is the final *Physics Flash* of 2017. The holiday season is starting. I wish all of you and your families a safe and happy season. And I remind you that this can be a season of distractions, so please pay extra attention to do your jobs safely and securely.

*Physics Division Leader David Meyerhofer*

\* “For her enormous contribution to the development of the Mexican physicists in the HAWC observatory and her contribution to the selection of Mexico to install the HAWC Observatory.”



### *Medina Jr., cont.*

Center (LANSCE) while pursuing his associate's degree in pre-engineering at The University of New Mexico-Los Alamos. After graduating, he became a full-time Los Alamos technician supporting both P-25 and P-23.

"He really had it together for a 21-year-old," said one of his close coworkers, Patrick Younk (P-23). "When we first hired him, he was telling me he bought a side-by-side (off-road vehicle). He really liked driving it out in the Peñasco foothills. I think he felt really proud that he had it together and could buy that. He was very classy and had tremendous potential."

As a member of Physics Division, Medina constructed photon Doppler velocimetry units for proton radiography experiments and helped develop broadband laser ranging systems to calculate velocities for explosives. He built instrumentation devices in use at LANSCE's Proton Radiography Facility and the Nevada National Security Site (NNSS) U1A subcritical experiment site. His Distinguished Performance Award was for a series of experiments that helped the Lab's Weapons Program—Medina set up the

proton beam, reconfigured equipment from one experiment to the next, and debugged the beam as needed.

In an interview shortly before his death, Medina discussed his plans to explore NNSS and ambitions for a successful career performing photon Doppler velocimetry. He was looking forward to doing timing velocimetry measurements for the classified subcritical experiment Vega, the final shot in the Gemini-Lyra underground test series.

He cited the phrase "you can do anything you put your mind to" as the best advice he'd ever received—advice that gave him confidence building instruments and "the motivation to do and become who I want to be in life," he said.

"We all found Patrick to be very sharp, and anticipated that he would be one of our stars. On top of that, he was very pleasant to work with—someone you were always glad to see walk in the door," said Matt Briggs, P-23's Defense Research and Technology team leader.

Medina is survived by his parents, Patrick and Yolanda, and sisters, Savannah Medina and Diana Blanco.

## **In memoriam: Geoff Mills**

### *A pioneer in neutrino detection*

*By H. Kris Fronzak, ADEPS Communications*

With his gentle disposition and an innate curiosity about the enigmas of the universe, Geoff Mills (Subatomic Physics, P-25) was held in high regard by particle physicists the world over. Mills passed away recently after an 18-month fight with pancreatic cancer.

"Geoff never lost faith that everything would work out in the end and he was almost always right," said fellow researcher Bill Louis (P-25) during a celebration of Mills's life. "He contributed so much to many experiments and to fundamental science. He was a brilliant physicist, a valued colleague, and a wonderful human being."

The greatest achievements in Mills's career were in neutrino science—the study of mysterious, near-massless subatomic particles that may contribute to dark matter. As a postdoctoral researcher at the European Organization for Nuclear Research (CERN), he made measurements confirming the existence of three flavors, or types, of neutrinos. As a Los Alamos researcher, he helped produce data supporting the existence of neutrino oscillations, which went against the Standard Model of physics and supported the idea of a fourth, sterile neutrino. The theory of a fourth neutrino flavor initially generated skepticism in the field of particle physics but is now gaining traction.



**Geoff Mills with the prototype of one of his experiments, a threshold Cherenkov detector that was deployed into the Neutrinos at the Main Injector beamline at Fermilab.**

"It takes a certain amount of toughness to ignore critics. For decades, there was a lot of ridicule associated with Geoff's research, but he followed the data. The legacy he left us pushes a new frontier of sterile neutrinos," said collaborator Richard Van de Water (P-25). "He was a pioneer in this field."

After making the controversial measurements proposing a sterile neutrino, Mills organized a research team to assess neutrino fluxes for the cutting-edge Deep Underground Neutrino Experiment at Fermi National Accelerator Laboratory, which is gearing up to hunt for undiscovered subatomic

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*Mills cont.*

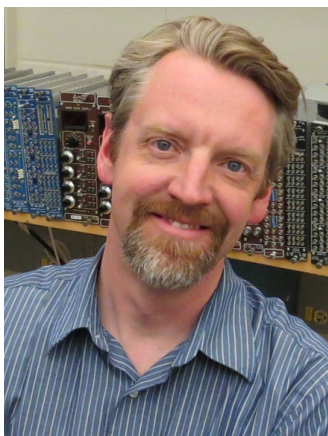
phenomena. Mills helped prepare three of the four liquid argon detectors housed at Fermilab to search for the sterile neutrino. He helped prompt the ICARUS detector's move from CERN to Fermilab, built the beryllium target for Mini-BooNE's Booster Neutrino Beamline, and contributed to the design of the Short-Baseline Near Detector's Photon Detection System. After his diagnosis, Mills remained committed to the project, and his efforts mean that all three detectors should be collecting data by 2020.

Mills is remembered as a sharp, unflappable colleague, a patient mentor, and a Renaissance man who was a skilled tennis player, musician, and linguist. He is survived by his wife of 39 years, Ellen, and his sons, Jonathan and Alex.

## Physics staff in the news

### *Newell receives 2016 Richard P. Feynman Innovation Prize*

Raymond (Ray) Newell (Applied Modern Physics, P-21), won the Laboratory's 2016 Richard P. Feynman Innovation Prize. The award recognizes his consistent scientific and technical leadership over the past several years commensurate with a senior technical leader at Los Alamos National Laboratory culminating with a significant commercialization success in the last year. The prize was awarded at the recent 2017 Los Alamos National Laboratory Outstanding Innovation Celebration.



Newell, P-21's Quantum Communications team leader, has two patents, six patents pending, and eight invention disclosures within recent years. His intellectual property is being actively pursued in a commercial partnership, and in a field—quantum communications—promising substantial impact in nearly all levels of individual, financial, and national security communications.

He was lead principal investigator on a Cooperative Research and Development Agreement with Whitewood Encryption Systems, where he and his team moved a random number generator from theoretical concept to practical implementation. The Entropy Engine, a plug-and-play computer card encryption device that fits most network servers, uses phenomenon of light known as photon bunching that creates an almost perfectly random, digitized signal so that it provides an inexhaustible stream of random numbers for cryptosystems. The jointly developed technology won a 2016 R&D 100 Award and is now being sold by Whitewood.

"Ray has been the leading figure across this entire team ... Ray's contribution has been very diverse and has included helping to launch the product, engaging members of the press and interacting with prospective customers," said Richard Moulds, Whitewood's vice president of strategy.

The award honors scientist Richard P. Feynman, an early contributor to science crucial to the Manhattan Project, who was defined by his creative approach to problem solving, unconventional perspective, and ability to communicate science to a broad audience. The prize is inspired and driven by this legacy and aims to build a culture of innovation and spirit of entrepreneurship at Los Alamos. This year's award celebrates entrepreneurs by recognizing a person or team who has transitioned a technology to market through a start-up company.

P-21 Group Leader Larry Schultz described Newell as an example of someone taking technology across the "valley of death," or taking it from the lab to the nation. "He has excelled at transforming technical invention into applied solutions, and the recent efforts of Ray and his team unquestionably delivered a solution that formed the foundation for a start-up venture," Schultz said.

*Technical contact: Ray Newell*

### *Haffey wins outstanding physics poster award at Lab's 2017 Student Symposium*

For research on a new method to actuate cell/tissue culture substrates, Kiersten Haffey (Applied Modern Physics, P-21) earned an outstanding physics poster award at the Lab's 17<sup>th</sup> Annual Student Symposium.

Haffey, mentored by Pulak Nath (P-21), is a senior studying biomedical engineering at the University of Wisconsin-Madison.



Her poster, "Non-pneumatic actuation of stretchable membranes for organ-on-chip applications" was one of more than 200 presentations at the event, which allows Lab students to present their research and to network and make professional contacts. Organized by the National Security Education Center Student Programs Office, this year's symposium, "Championing Scientific Careers" was held at the University of New Mexico—Los Alamos.

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### *In the news cont.*

Organ-on-a-chip platforms are set to revolutionize how researchers study disease models and perform drug testing to develop pharmaceuticals. However, existing methods of integrating mechanical actuation—required to recapitulate key features of human tissue microenvironment—require cumbersome and limiting tools such as pneumatic sources, clamps, and electro-mechanical components. To overcome this challenge, Haffey and her coworkers developed a non-pneumatic method that uses microfluidic aspiration to actuate cell/tissue culture substrates. The microfluidic aspirator uses a sudden expansion in the cross-sectional area of a liquid flow path to cause a pressure drop, resulting in a fluid-structure interaction that bulges the integrated stretchable membrane. The strain of the stretched membrane depends on the flow rate and the elastic properties of the membrane. The microfluidic aspirator was used to culture human alveolar epithelial cells under 5% stretch for 24 hours, making the method useful for cell culture. The strain can be maintained within 1% of the desired strain over long-term culture periods, i.e., 14 days.

Her work, which supports the Lab's Energy Security and Nuclear Deterrence missions and the Materials for the Future science pillar, was funded by the DOE's Science Undergraduate Laboratory Internships program and the Defense Threat Reduction Agency's RAM-ATHENA program.

*Technical contact: Kiersten Haffey*

### *Physics Division staff awarded for distinguished performance*

Thirty-five members of Physics Division received 2016 Los Alamos National Laboratory Distinguished Performance Awards, acknowledging their outstanding contributions to the Laboratory's programmatic efforts.



#### **Small team awards**

##### **Fuel Cask Tomography Team**

Jeffrey Bacon, Matthew J. Durham, Elena Guardincerri, and Daniel Poulson (Subatomic Physics, P-25), demonstrated that nuclear fuel stored in unopened casks can be monitored

using muon tomography, solving a long-standing nuclear safeguards problem.

Spent reactor fuel is stored long-term in dry casks—leak-tight steel containers shielded by additional material, which are then monitored with seals, video surveillance, and inspections to ensure the casks' integrity. If surveillance fails or seals are damaged, however, no foolproof way exists to check a cask's contents without opening it. The Fuel Cask Tomography Team used muon particles to penetrate a cask, then measured the difference between the particles' angle of entrance to the cask and the angle of exit after being deflected by the cask's contents. The technique produced an aerial-density image revealing the fuel's presence or absence.

In 2015 team members used equipment they had on hand to establish proof of principle for this method of cask monitoring. In 2016 with more-refined techniques, they made measurements so precise that they could identify the exact number and placement of fuel rods in an unopened cask. The team's accomplishment was the first nondestructive assay of a fuel cask and proves that muon tomography can reestablish continuity of knowledge if the usual monitoring fails.



##### **Ultracold Neutron Source Team**

In 2016 the Ultracold Neutron (UCN) Source Team—Steve Clayton, Scott Currie, Takeyasu Ito, Mark Makela, John Ramsey, and Andy Saunders (P-25)—completed a three-year upgrade of the UCN Source facility at the Los Alamos Neutron Science Center (LANSCE), making it the highest-density ultracold neutron source in the world. With the upgrade, the facility can support investigations complementary to or competitive with precise low-energy particle physics experiments at high-energy colliders such as CERN's Large Hadron Collider. The facility can precisely measure the neutron lifetime, a measurement essential to testing the Standard Model of particle physics.

Thanks to this team's upgrade, UCN's user program is rapidly growing and attracting collaborators from external

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In the news cont.



institutions, including the California Institute of Technology, Indiana University, the University of Kentucky, the University of Michigan, North Carolina University, Princeton University, and Virginia Tech. This collaborative research has enabled 11 graduate students to obtain their PhDs, and provided 5 others with data for their theses. The upgraded facility is supporting world-class science, training the next generation of scientists, and serving as a pipeline for bringing new talent to the Laboratory.

#### Large team award

##### The pRad Experimental 0631 Team

The Proton Radiography (pRad) Experimental 0631 Team brought a weapons-related experiment from concept to completion in less than three months. The idea for Experiment 0631 emerged from a Lab-wide meeting of Weapons Program participants, which addressed the need for experimental data to solve a substantial issue of interest to the program. The idea resulted in a call for an experiment at the Los Alamos Neutron Science Center (LANSCE) pRad facility.

The experiment team, which included members of Applied Modern Physics (P-21), Neutron Science and Technology (P-23), Plasma Physics (P-24), and Subatomic Physics (P-25), faced difficult challenges. These included a tight beam schedule and the availability of facilities and workers responsible for all aspects for preparation—from manufacturing and procuring parts, machining conventional and high explosives, completing the experimental assembly, deploying diagnostics, to executing a proof shot checking the design's safety.

Team members were ready to execute the experiment on February 20, 2016—the last possible date available to them. The experiment provided the Lab's Weapons Program with a unique dataset in an unpredicted area that will be further explored. It also resulted in efforts to restore small-scale plutonium experiments at the pRad facility, and serves as a reminder of what Los Alamos can accomplish in the face of unprecedented challenges.

Physics Division team members are Sky Sjue (P-21); William Buttler, Matthew Freeman, John Goett, Bob King, Anna Llobet Megias, Ruben Manzanares, Frank Merrill, Matthew Murray, Paul Nedrow, Jeremy Payton, Leonard Tabaka, Joshua Tybo, and Carl Wilde (P-23); John Oertel (P-24); Christopher Morris, Alexander Saunders, Amy Tainter, Dale Tupa, Julian Lopez, Levi Neukirch, Jason Medina, Tamsen Schurman, Frans Trouw, and Fesseha Mariam (P-25).

Other team members were from Focused Experiments (J-3), HE Machining and P&T (J-8), Experiments Integration Office (J-EI), Shock and Detonation Physics (M-9), Engineered Materials (MST-7), Weapons Facilities (WFO-WF), XTD Primary Physics (XTD-PR1), and Institutional Systems Services (XIT-ISS).

### Muon detector developed for subsurface borehole imaging

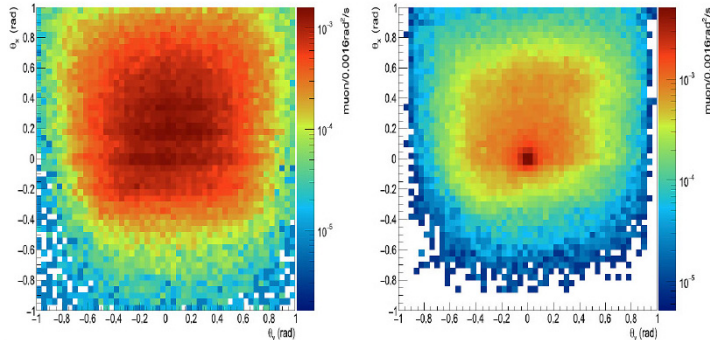
A research team is examining how cosmic ray muon tomography could precisely and completely image the density distribution in the Earth's subsurface to provide a direct, real-time, and low-cost method for monitoring fluid displacement in subsurface reservoirs. Such technology could also observe the sequestration of the greenhouse gas carbon dioxide (CO<sub>2</sub>) and track fluid migration during injection or hydrocarbon production. These are timely applications given concerns about such as human-induced seismicity and chemical leakage into aquifers. The journal *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* has published the developmental work.

Muons are generated naturally in the upper atmosphere from cosmic ray interactions. Due to their high energies, ubiquitous availability, and highly penetrating nature, scientists are studying them for a variety of difficult imaging scenarios. The muons penetrate into the Earth at multiple angles and are attenuated by the different stratigraphic units

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## Muon detector cont.



**Data for the tunnel at the Laboratory's TA-41 tunnel. (Left): angular muon flux for the prototype Borehole Muon Detector. (Right): the Monte Carlo GEANT4 simulation. The tunnel entrance is toward the top.**

depending on their densities. By measuring the muon flux at various depths in vertical, inclined, or horizontal wells, the attenuation of the muon signal due to the different stratigraphic units, or the fluids contained within these units, can be determined. These measurements could identify and interpret variations in density and fluid content as a function of time, and be processed and interpreted jointly with other geophysical data to improve spatial resolution and reduce uncertainty.

This approach has the potential to become a direct, real-time, and low-cost method for monitoring fluid displacement in subsurface reservoirs. In the example of geological carbon storage, such a method would enable monitoring the CO<sub>2</sub> concentration by observing density changes over time as the CO<sub>2</sub> is injected and replaces brine. The muon detector for such an application needs to have sufficient angular resolution as well as high efficiency due to the low muon flux values at the depths at which CO<sub>2</sub> would be stored.

Strict requirements of size, ability to withstand an underground environment, data transmission rate limitations, background effects, and performance requirements guide the development of a miniaturized muon-tracking detector deployed in a borehole. The primary technical challenges for the design include: 1) a miniaturized detectors capable of fitting in standard seven-inch diameter boreholes and 2) resisting the harsh underground conditions (e.g., pressure, heat, water, corrosive chemicals) for long periods of time.

To test the viability of this technique, researchers developed and tested a muon detector designed to function in boreholes. The inventors used the Monte Carlo code GEANT4 to simulate the anticipated detector response and tested the prototype Borehole Muon Detector in the Shallow Underground Laboratory at the Pacific Northwest National Laboratory and in the underground tunnel at Los Alamos's Technical Area 41. The Los Alamos tunnel is a decommissioned drift in the Bandelier Tuff units in Los Alamos Canyon, with

a floor approximately 90 m below the mesa top above, and extending approximately 90 m into the side of the mesa. Los Alamos investigators used their expertise in muon imaging and particle detectors to run the Borehole Muon Detector against the Lab's well-characterized larger detector known as the Mini-Muon Tracker, which Subatomic Physics (P-25) researchers operate. The Los Alamos researchers also analyzed data from the larger Mini-Muon Tracker to benchmark the borehole detector.

The Borehole Muon Detector system provided data acquisition sensitivity comparable to that of the Mini-Muon Tracker. This comparison has proved the technical and economic feasibility of a Borehole Muon Detector system, which is considerably smaller, lighter, and more portable than the Mini-Muon Tracker. Numerical modeling suggests the Borehole Muon Detector would be able to detect small changes in density, which are a proxy for fluid migration, as deep as 1,500 meters, which can be localized by the use of several detectors allowing researchers to build a tomographic image. The researchers have already developed a version that will be small enough for testing in a typical seven-inch-diameter borehole environment. The new design concept could fit into a pressure vessel with an outside diameter of six inches.

Reference: "A Novel Muon Detector for Borehole Density Tomography," *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* **851**, 108 (2017). Authors: Alain Bonneville, Richard T. Kouzes, and Jared Yamaoka (Pacific Northwest National Laboratory); Charlotte Rowe (Geophysics, EES-17); Elena Guardincerri, J. Matthew Durham, Christopher L. Morris, Daniel C. Poulson, and Jeffrey D. Bacon (Subatomic Physics, P-25); Deborah J. Morley (former LANL, now retired); Kenie Plaud-Ramos (former LANL student); James Byne, Julien Cercillieux, Chris Ketter, Khanh Le, Isar Mostafanezhad, and Gary Varner (University of Hawaii at Manoa, Honolulu); Joshua Flygare and Azaree T. Lintereur (University of Utah, Salt Lake City). Pacific Northwest National Laboratory led the cosmic ray muon project. Los Alamos Principal Investigator (PI) Charlotte Rowe (Geophysics, EES-17) and co-PI Elena Guardincerri (P-25) managed Los Alamos National Laboratory's participation in the research.

The DOE's Subsurface Science, Technology and Engineering Research, and Development (SubTER) Crosscut program funded the work. The research supports the Laboratory's Energy Security mission area and its Science of Signatures science pillar via development of the capability to make measurements associated with environmental storage of CO<sub>2</sub> and hydrocarbon production.

*Technical contact: Elena Guardincerri*

## Multi-laboratory assessment verifies reaction history accuracy from past nuclear events

In 2015 the Reaction History Working Group formed to facilitate direct working exchanges and joint projects between Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and National Security Technologies (NSTec) including Nevada National Security Site (NNSS).

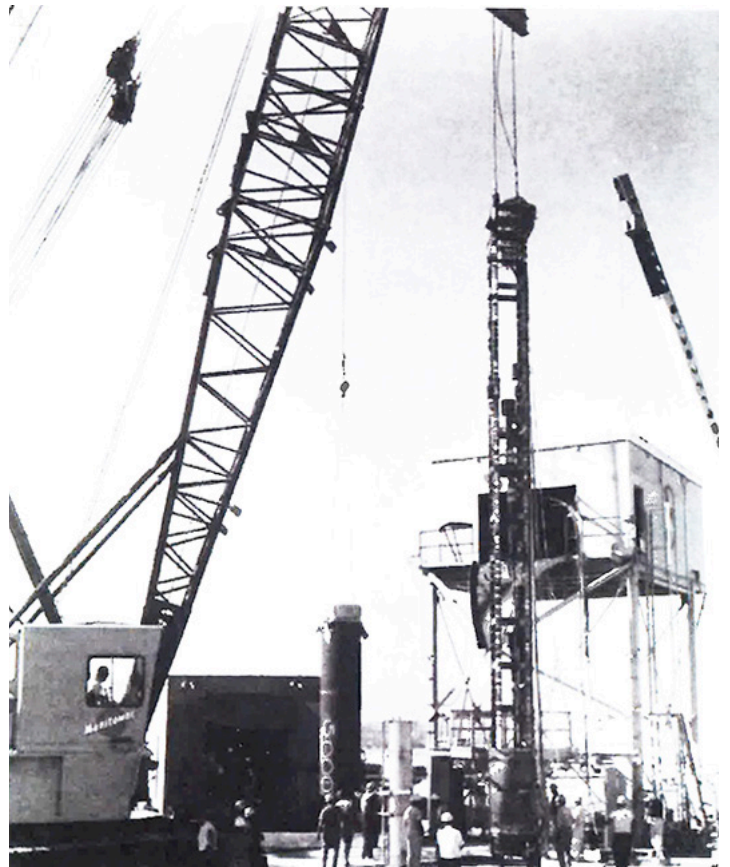
An archival photo shows transportation of a rack in preparation for the Auk nuclear event at the Nevada Test Site in 1964. Gamma and neutron detectors were placed on such racks.

LANL and LLNL recorded gamma reaction history data from about 870 underground nuclear events during the underground testing era, 1963-1992. During a nuclear event, gamma detectors of various kinds, including photodiodes and detectors based on the Compton effect, provided data as a function of time (called reaction history). In the subsequent decades, independent reaction history analysis software was developed and used by LANL personnel and a combination of researchers from LLNL and NNSS/NSTec. Computing capabilities now available in the Advanced Simulations and Computing (ASC) era are very different than anything available during the time the tests took place. Therefore, current researchers are able to extract much more information from the recorded data than was possible immediately after a nuclear event.

The two laboratories compared the output from the independent software. They exchanged raw data from three nuclear events and compared analyzed results. The results agreed within the quoted uncertainty for all the events. This level of agreement gives the laboratories additional confidence that the analyses are being performed correctly and are free of systematic errors. The LANL and LLNL/NNSS teams plan to extend the study by adding additional events to analyze, and the Atomic Weapons Establishment (AWE) UK has expressed interest in joining the study using their independently developed software.

This knowledge is particularly important because the comparisons of analyzed reaction history results to simulations are a key metric in characterizing the accuracy of weapon modeling, such as in baseline development for the Annual Assessment. NNSA's Verification and Validation, ASC, Science Campaigns, Weapons Annual Assessments, and the Life Extension Projects benefit from this comparison.

Fred Wysocki (LANL Verification and Validation Program Manager, under the Advanced Simulations and Computing Program) led the Los Alamos participants. Dave Anderson (LLNL), Hanna Makaruk (Applied Modern Physics, P-21), and Ding Yuan (NNSS) performed the comparisons. Other



**An archival photo shows transportation of a rack in preparation for the Auk nuclear event at the Nevada Test Site in 1964. Gamma and neutron detectors were placed on such racks.**

Reaction History Working Group participants include Tanim Islam, Dave Stevens, Mark May, Matt Buckner, and Don Smith (LLNL); Jerome Blair (NSTec); Bob Berglin (NNSS); Mike Ham, Michael Malone, and Yvette Maes (P-21); and Doug Thayer (P-21 and NSTec).

The NNSA funded the work, which supports Los Alamos's Nuclear Deterrence mission area and the Nuclear and Particle Futures science pillar.

*Technical contact: Hanna Makaruk*

## Neutrino research beaming forward with DUNE

*Experiment to send particles 800 miles through the earth from Illinois to South Dakota*

An international group of researchers and dignitaries broke ground recently on construction of a massive experiment that could change our understanding of the universe.

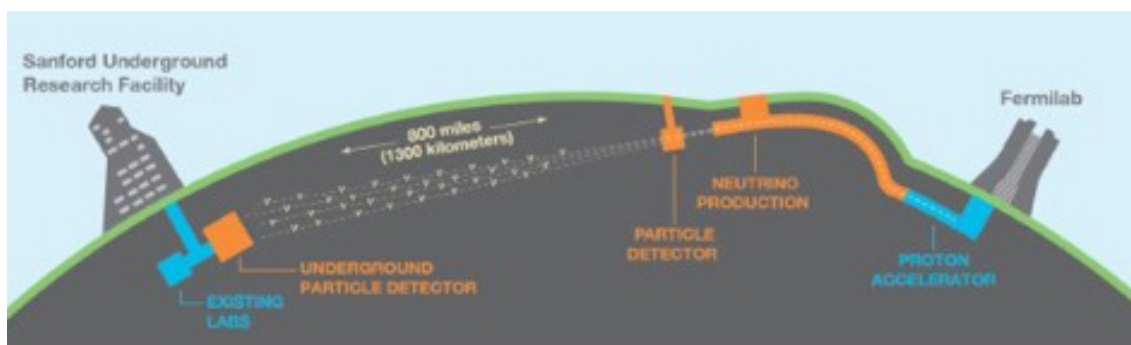
The Deep Underground Neutrino Experiment (DUNE), the largest experiment ever built in the United States to study neutrinos, is engaging the expertise of Physics Division to develop and manage near-detector systems. Three "fla-

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Neutrino cont.

**Illustration of the planned path for the Deep Underground Neutrino Experiment, which will investigate the existence of a sterile neutrino. Photo courtesy Fermilab.**



vors” of neutrinos—elusive subatomic particles that interact weakly with matter—are known to exist. A proposed fourth flavor, the sterile neutrino, could serve as a candidate for dark matter, helping to explain how the universe works and why matter exists at all.

The Long-Baseline Neutrino Facility (LBNF) at South Dakota’s Sanford Underground Research Facility will house the DUNE experiment. DUNE begins with a proton accelerator at Fermi National Accelerator Laboratory (Fermilab) in Illinois that will send a beam of neutrinos through two detectors. A detector located at Fermilab records particle interactions near the source of the beam. The beam will travel 800 miles through the earth to a second detector built almost one mile underground, filled with 70,000 tons of liquid argon. This detector will capture images of the interactions deep underground so scientists can study the interactions between neutrinos and argon atoms.

For decades, Los Alamos researchers have been engaged in neutrino research, starting from the 1956 discovery of the particles’ existence. Since then, the Lab helped prove that neutrinos oscillate and have mass. For this ambitious

project, Lab researchers have been performing R&D on the target material, liquid argon, and are working to accurately monitor the neutrino beam. DUNE was conceived, designed, and will be built by 1,000 scientists and engineers from more than 160 institutions. This research is funded by the DOE Office of Science in conjunction with the European research center CERN and international partners from nearly 30 countries. Nuclear physics is a key component in Los Alamos’s mission to ensure that the nation’s nuclear stockpile is safe, reliable, and secure. The work supports the Laboratory’s Nuclear and Particle Futures science pillar.

Los Alamos researchers involved in this international collaboration include Robert Cooper, Gerald Garvey, Elena Guardincerri, En-Chuan Huang, William Louis, and Richard Van de Water (Subatomic Physics, P-25); Keith Rielage (Neutron Science and Technology, P-23); Gus Sinnis (Experimental Physical Sciences, ADEPS); and Charles Taylor (Accelerator Operations, AOT-OPS). The work, funded by the Department of Energy High Energy Physics program, supports the Laboratory’s Energy Security mission.

*Technical contact: William Louis III*

## Neutron capture measurements using DANCE improve cross section calculations

New measurements of neutron capture cross sections (reaction probabilities) and gamma-ray emission spectra completed over several years at Los Alamos Neutron Science Center (LANSCE) have resolved some measurement discrepancies and provided the experimental basis for lab theoreticians to improve the models used to calculate neutron capture.

These measurements of uranium isotopes were made using LANSCE’s Detector for Advanced Neutron Capture Experiments (DANCE). The improved models may have wide applications in calculating neutron capture for modeling explosion performance, reactor design, test diagnostics, and nuclear forensics.

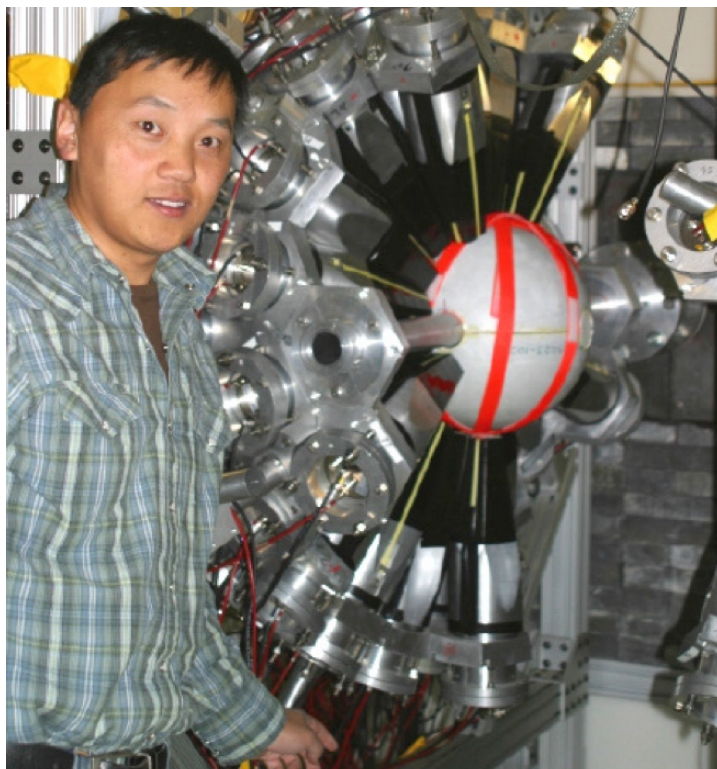
Many capture cross section measurements have been made, but researchers still see discrepancies between the data, even in  $^{235}\text{U}$ , a well-studied nuclide. Measurements are further complicated by the radioactive decay that produces a detector background and limits the amount of material that can be measured.

The advanced DANCE detector has allowed Los Alamos researchers and their collaborators to measure the  $^{235}\text{U}$  capture cross-section and resolve an important discrepancy in the 1 to 5 keV energy region. The team also published measurements on  $^{236}\text{U}$  and  $^{238}\text{U}$  and is currently analyzing a measurement of  $^{234}\text{U}$ .

Gamma-ray emission spectra provide an important constraint on the calculations, and the team is analyzing the gamma-ray spectrum from  $^{235}\text{U}$  capture to extend the theoretical analysis to isotopes that have a fission contribution. The ultimate goal is to make accurate capture calculations for nuclei that cannot be measured, such as  $^{237}\text{U}$  and  $^{239}\text{U}$ . DANCE spectra have

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## Neutron capture cont.



The DANCE detector, opened to show individual crystals. This large-area advanced detector, coupled with the intense neutron flux at the Lujan Center, was crucial in making these measurements.

confirmed that an additional mode of nuclear excitation—the “scissors mode,” which has been observed in measurements of other nuclear reactions—is required to reproduce the observed gamma-ray spectra.

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Researchers: John Ullmann, A. Couture, R.C. Haight, Shea Mosby, J.M. O’Donnell (LANSCE Weapons Physics, P-27); M. Jandel, T.A. Bredeweg, B. Baramsai, G. Rusev, R.S. Rundberg, D.J. Vieira, J.B. Wilhelmy (Nuclear and Radiochemistry, C-NR); and T. Kawano and M. Mumpower (Nuclear and Particle Physics, Astrophysics and Cosmology, T-2). Additional contributions were made by C.Y. Wu (Lawrence Livermore National Laboratory), A. Chyzh, G.E. Mitchell (North Carolina State University), and M. Kricka (The Charles University in Prague).

References: “New Precision Measurement of the  $^{235}\text{U}$  ( $n; \gamma$ ) Cross Section,” *Physical Review Letters* **109**, (2012).  
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Technical contact: John Ullmann

## Celebrating service

Congratulations to the following Physics Division employees recently celebrating service anniversaries:

William Louis, P-25.....	30 years
Hans Herrmann, P-24.....	20 years
Jeffrey Bacon, P-25.....	15 years
Malcolm Boshier, P-21.....	15 years
Matthew Briggs, P-23.....	15 years
Jason Medina, P-25.....	15 years
Algis Urbaitis, P-21.....	15 years
Michael Ham, P-21.....	10 years
John Goett, P-23.....	5 years



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## Los Alamos recognized as top diversity employer

For the second straight year, Los Alamos National Laboratory was recognized as a top diversity employer by *LATINA Style* and *STEM Workforce Diversity* magazines. Los Alamos rose in ranking to 10 on *STEM Workforce Diversity* magazine's Top Government Employers list and to 41 on *LATINA Style*'s Top 50 Companies list.

"We are pleased that the Laboratory is being recognized for its efforts to build a diverse and engaged workforce. This is an integral aspect of our staffing plans," said Carol Burns, deputy principal associate director for Science, Technology, and Engineering. "Diversity in our workforce gives us diversity in our perspective and thinking about the challenging problems inherent to our missions. It makes us more innovative."

On the list of Top 20 government employers, Los Alamos was named among agencies such as NASA and the National Institutes of Health. On *LATINA Style*'s Top 50 Companies, the Laboratory was named alongside the likes of AT&T, Hilton, and State Farm.

Learn more at [www.lanl.gov/discover/news-release-archive/2017/September/0919-top-diversity-employer.php](http://www.lanl.gov/discover/news-release-archive/2017/September/0919-top-diversity-employer.php).

## HeadsUP!

Your Physics Division WSST is...

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**Chair:** Christine War, [cwar@lanl.gov](mailto:cwar@lanl.gov)

**Co-chair:** Gerri Barela, [gbarela@lanl.gov](mailto:gbarela@lanl.gov)

The Physics Division WSST meets once a month, generally on the second Wednesday at 3 p.m. in TA-53, Bldg. 1, Rm. D105. WSST meetings are open to everyone. You are invited to attend and share your safety and security concerns and suggestions.

